halogen derivatives, whence it follows that for these the ratio of the increase of mean total energy to the increase of kinetic energy of translation of the molecule is proportional to the number of atoms in the molecule.

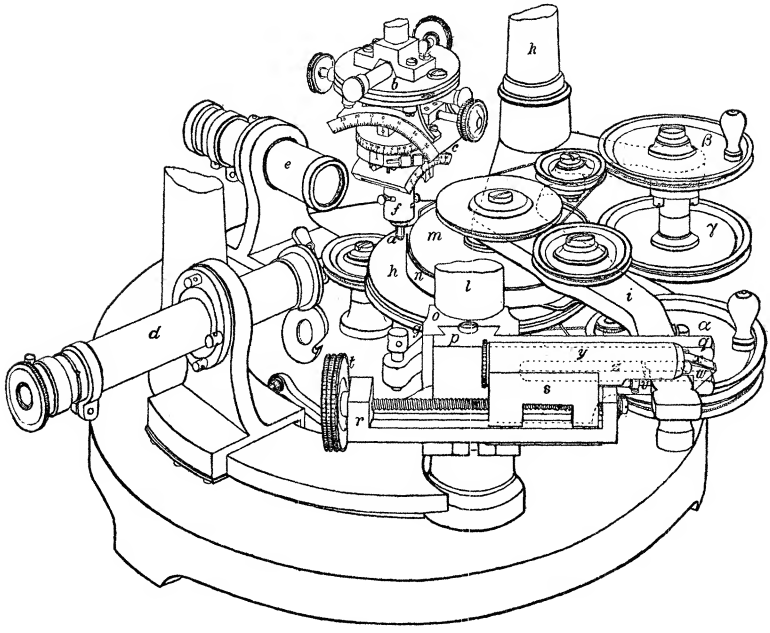
IV. "An Instrument for Cutting, Grinding, and Polishing Section-plates and Prisms of Mineral or other Crystals Accurately in the Desired Directions." By A. E. TUTTON, Assoc. R.C.S., Demonstrator of Chemistry at the Royal College of Science, South Kensington. Communicated by Professor JUDD, F.R.S. Received November 28, 1894.

(Abstract.)

In a recent communication ('Phil. Trans.,' 1894, Series A, p. 887; 'Roy. Soc. Proc.,' vol. 55, p. 108) the author described an instrument for grinding accurately orientated section-plates and prisms of crystals of artificial preparations. The success of that instrument is so complete that another instrument has been devised and constructed, upon similar principles, but with the necessary modifications and additions, to enable equally accurately orientated plates or prisms to be prepared from the relatively harder crystals of natural minerals.

The new instrument is constructed upon a scale one-fifth larger than the former one as regards such parts as are fundamentally similar, to confer greater strength. The main innovations are those of a cutting apparatus, capable of ready removal, in order not to impede goniometrical, grinding, and polishing operations, and a much larger grinding table fitted with a particularly convenient mode of attachment for any one of nine interchangeable grinding and polishing laps, suitable for use with crystals of every degree of hardness. The accompanying illustration represents the lower portion of the instrument, drawn from a point sufficiently high above the base to most clearly exhibit the arrangement of the cutting apparatus. The instrument is not intended to replace the one previously described, which is fully adapted to all the uses of chemical crystallographers, and the cost of which is only two-thirds that of the one now described. It is intended especially for the use of mineralogists, but, naturally, will likewise serve all the purposes of the smaller instrument.

The mode of supporting the outer fixed cone within which the movable axes rotate, the construction of the circle and its axis and fine adjustment, and of the gun-metal axis and its counterpoising levers designed for controlling the pressure between crystal and lap, as also of the inner steel axis from which are suspended the crystal *a*



Instrument for Cutting, Grinding, and Polishing Section-plates and Prisms of Mineral or other Crystals.

and its centering (*b*) and adjusting (*c*) movements, are similar in principle to the corresponding arrangements in the smaller instrument, although many details are altered for the sake of greater rigidity. The same likewise applies to the goniometrical telescope *d* and collimator *e* and their mode of support.

The crystal holders, in addition to being provided with cross-grooved surfaces for the reception of the cementing wax, which should be the hardest variety used by opticians, are further provided with protecting rims, so that the wax is firmly held in a shallow cup. Three ordinary holders are supplied, of $\frac{5}{16}$, $\frac{5}{8}$, and $\frac{7}{8}$ in. diameter respectively. Two holders, of $\frac{5}{16}$ and $\frac{1}{2}$ in. diameter, are also furnished, which permit of a certain amount of rotation of the crystal after fixation of the holder in its socket, as described in the former communication, and one of which is shown in position at *f* in the illustration. Also there is the special holder for use in grinding a second surface parallel to the one first prepared, and it is provided with two lower caps pierced by apertures of $\frac{9}{16}$ and $\frac{5}{16}$ in. respectively, together with a dozen glass discs ground to fit each.

The grinding apparatus resembles that of the smaller instrument,

as far as the driving gear and the mode of supporting the grinding table are concerned. The table itself is much larger however, the laps being 4½ ins. in diameter, and it is differently constructed, in order to permit of rapid change from one lap to another. The table is provided with a permanent rigid gun-metal top *g*, slightly larger than the laps, upon which the latter are laid. The laps carry below three cylindrical projections, which pass through corresponding holes in the table, and they may be locked in this position by a plate carried beneath the table, and which is rotatable for a sufficient amount by a rack and pinion actuated by a short lever; the plate is pierced by tapering slots, wide enough at one end to allow the projections to fall through or be removed, but narrowed at the other so as to gear in niches cut in the projections. The lap *h* is placed in position, or lifted out when it is desired to remove it, while the lever is rotated outwards radially to the axis of the table; upon rotating the lever inwards again, as far as a stop permits it to go under the table, the lap, if in position, will be firmly locked to the latter.

Four metallic laps are provided; one of iron, for rough grinding with coarse emery and brick oil or water; two of gun-metal and hard white metal respectively, for fine grinding with flour emery; and another of pewter, for polishing with rottenstone and water. A polishing lap of hard felt, for use with putty powder and water, and a lap of boxwood, either for grinding soft mineral crystals or for polishing, are likewise supplied. There are also three glass laps for use with artificial crystals, one moderately ground for rough grinding, the second extremely finely ground, and another of plain plate glass, the last two for polishing, and all three to be lubricated with oil. The final polisher of ordinary plate glass furnishes admirably polished surfaces, and best of all when the amount of oil is extremely small.

The cutting apparatus is carried at a suitable height above the level of the grinding table upon a rigid horizontal arm pivoted upon the back pillar *k* of the instrument, so that it can be completely rotated out of the way during grinding operations, and further supported when required for use upon an adjunct of the right front pillar *l*. It consists of a 4-in. disc of soft iron *m*, supplied with diamond edge, and intended to be lubricated with brick oil, supported truly parallel to the grinding table between two stout broad washers, carried by the almost frictionless axle, and driven by an independent driving gear; the latter is somewhat similarly arranged to that of the grinding apparatus, in order that the pressure of the band round the pulley which turns with the axle of the cutter shall be equal on each side to minimise friction, and is entirely carried upon the arm. The latter is bent inwards towards the crystal, so that the cutting edge may be conveniently approached.

Three interchangeable cutting discs are supplied, one of the usual thickness of a lapidary's cutter, and two somewhat thicker, which are preferable on account of their greater rigidity; their edges are carefully squared and charged with diamond dust in the usual manner. In order to protect the instrument from particles projected during cutting, the disc is surrounded, except in the vicinity of the crystal, with a readily removable guard *n*. A second larger guard is also supplied in order to afford more complete protection to the optical tubes; it consists of a thin metal disc considerably larger than the grinding table, upon which it is intended to rest, and fitted round one-half of its circumference with a rim $1\frac{3}{4}$ in. high, sufficient to protect the telescope and collimator, while not interfering with the freedom of movement of the arm of the cutting apparatus. The support upon the front pillar is removable when the cutter is not in use, so as to leave room for grinding; the pillar carries in front at the convenient height a rectangular thickening *o*, out of which a vertical dove-tailed recess is cut, within which a corresponding dove-tail *p*, forming the back portion of the main casting of the attachment, is capable of sliding until arrested at the proper height, corresponding to the perfectly horizontal position of the cutter and its arm, by a stop.

This attachment includes not only the supporting fork *q* for the arm, but also the apparatus for directing and controlling the cutting. The latter consists of a horizontal traversing bed *r* and slider *s*, manipulated by the large milled head *t* of the traversing screw; the arm is attached to the slider by being gripped between a small spring piston *v* and a hinged wedge-shaped hook *w*, the latter being so shaped in order that it may be pushed out of the way while the arm passes it, after which a spring *x* causes it to fall down behind the arm. This gripping arrangement is carried by a much larger piston, retained by a strong spring in a cylinder *y* fixed to the slider. The possibility of undue pressure being developed between cutter and crystal, owing to injudiciously rapid rotation of the traversing screw, is thus avoided, the spring giving way before the pressure becomes dangerously great and the piston being pulled out of the cylinder. Two inches of traverse are permitted by the length of the slot *z* of the fork and of the traversing bed of the slider, an amount ample to permit of the cutting through of a crystal an inch in diameter.

This form of cutting apparatus is found to work admirably; there is no tendency to jamming when once the operator has become familiar with the rate at which the milled head of the traversing apparatus can most advantageously be rotated, and the cutting is more perfectly under control than when the pressure of the cutter against the crystal is brought about by a spring or a weight hanging over a pulley.

The adjustment of the crystal, so that the direction of the desired

surface is exactly parallel to the cutting disc and grinding lap, is carried out as described in the former communication. When about to commence cutting, the crystal is first lowered by means of the milled head at the top of the instrument until it is at a convenient level for cutting, in which position it is fixed by first clamping the circle to the fixed cone by means of the milled headed screw forming part of the arrangement for fine adjustment, and then preventing any movement of the gun-metal axis by tightening the collar immediately above the circle by means of a key provided. Cutting is then proceeded with, commencing rotation of the cutter and its traversing slowly at first, and gradually increasing the speed according to the "feel" of the cutting. If by inadvertence a jam should ever occur, a slight reversal of the motion of the traversing screw will instantly release the cutter. The speed should be materially reduced towards the finish, in order that the end of the crystal may be cut off cleanly right up to the furthest edge. A hard crystal such as a topaz, $\frac{1}{2}$ in. thick, may be easily cut through in 10 to 15 minutes, and the cut surface is so smooth that very little grinding is required, which may at once be proceeded with upon the gun-metal or hard white-metal lap, with the finest washed flour emery made into a moderately thick paste with water or brick-oil. The latter lubricant offers the advantage of greater immunity from splashing, although not perhaps so convenient in other respects.

A thick glass disc, about 1 in. in diameter, is provided for use as a "bruiser," to work down the emery paste to an even consistency upon the lap before grinding. The pressure between crystal and lap is controlled by manipulation of the counterpoised levers, as described in the former memoir, and the path of the crystal upon the lap changed from time to time by use of the centering movements, in order to prevent undue local wearing of the lap.

A further useful accessory is a small stand consisting of a weighted base carrying an upright tubular stem, in which a lengthening rod is capable of sliding, which latter carries an adjustable support, formed by a couple of short links united by ball-and-socket joints, for an oblique caoutchouc wedge. The latter, when directed down upon the lap, not quite in contact with the metallic surface of the latter, serves to keep the emery paste moving into the path of the crystal during grinding. When soft artificial crystals are being ground upon the glass laps, the wedge may be replaced by a camel-hair brush, to keep the path well supplied with the lubricating oil.

The surfaces prepared by the fine grinding are usually sufficiently transparent for the purposes of optical investigations, plates perpendicular to the median lines exhibiting clearly defined interference figures in convergent polarised light. If a higher polish is desired, the polishing laps supplied will enable this to be attained.

After the completion of the operations upon the first surface, the cutting of the second is proceeded with while the crystal is still adjusted, the latter being fixed at the suitable height for the purpose. The plate thus cut off is cemented by the finished surface to one of the small glass discs provided with the special holder, and the finishing of the second surface carried out with the disc supported in the holder, whose true plane has previously been adjusted parallel to the lap, as described in the former communication.

When a prism is to be prepared the crystal is first adjusted so that the plane of optical elasticity to which the two desired prism faces are to be symmetrical is parallel to the grinding lap, and likewise so that the direction of the desired edge, parallel to an axis of optical elasticity, is at right angles to the upper tangent screw of the adjusting apparatus. The latter is then rotated 30°, the crystal arranged at the convenient height for cutting, and the end cut off. The cut surface is then finished upon the laps. The tangent screw is next rotated back to the adjusted position, and for 30° upon the other side of that, when, after fixing at the proper height, the second surface is cut. The 60° prism thus cut off is again set in wax on the holder with the second surface exposed, and the latter is then brought parallel to the lap by goniometrical adjustment, and ground and polished, if desired, in like manner to the first. The two surfaces will invariably afford brilliant single reflected images of the spectrometer slit, and transmit equally well-defined refracted images when arranged for minimum deviation.

Instead of actuating the driving gear of the cutting or grinding apparatus by hand, which, however, is very light labour owing to the freedom from friction, a small electric, gas, or water motor may be employed. For this purpose the driving wheel α of the grinding apparatus is supplied with two annular niches, the upper of which is intended for the reception of the band from the motor; and two similar driving pulleys, one, β, for hand rotation, and the other, γ, for use with the motor, are fitted at the two ends of the driving axle of the cutting apparatus, that for hand driving being above the arm at the level of the other pulleys of the cutting apparatus, and that for the reception of the band from the motor being arranged below the arm, at the level of the upper niche of the grinding pulley. A small electric motor, driven by the current from three pint bichromate cells, affords ample power for the purpose, and the speed of revolution is best controlled by a friction brake upon the motor.

The instrument has been constructed by Messrs. Troughton and Simms, who are prepared to furnish copies of either this or the smaller instrument. The author desires to express his thanks to Mr. Skinner, of the Charlton Works, for invaluable assistance in devising it, and to Mr. F. Chapman, of the geological laboratory of

the Royal College of Science, for the benefit of his large experience in the cutting and grinding of minerals. The first model of the instrument is exhibited in the Science Division of the South Kensington Museum.

V. "Note on the Disease of Cabbages and allied Plants known as 'Finger and Toe,' &c." By GEORGE MASSEE, a Principal Assistant, Royal Gardens, Kew. Communicated by W. T. THISELTON DYER, Esq., F.R.S., Director. Received January 25, 1895.

The disease known in different parts of Britain as "finger and toe," "clubbing," or "anbury," attacks turnips, rape, cabbages of all varieties, radishes, and, in fact, most cultivated plants belonging to the order *Cruciferæ*. Several common weeds are also attacked, namely, charlock (*Brassica Sinapistrum*, Boiss.), garlic-mustard (*Sisymbrium Alliaria*, Scop.), treacle-mustard (*Erysimum Cheiranthoides*, Linn.), and shepherd's purse (*Capsella bursa-pastoris*, D.C.). The last-named is reported from the United States by Halsted,* and has not been observed to be diseased in Britain, although one of our commonest weeds. The disease is characterised by the formation of numerous nodules on the root, which becomes much distorted and soon decays, forming a slimy, fœtid mass.

Berkeley† appears to have been the first to investigate the disease from a scientific standpoint, and although he did not succeed in determining the true cause, distinctly states that microscopic examination revealed the presence of a factor previously unknown in connection with plant diseases. Furthermore, Berkeley pointed out that wood ashes were a cure for the disease, and supposed this to be due to the presence of potash salts in the ash.

Owing to the serious amount of damage caused by "finger and toe" to the cabbage crop in Russia, the Government of that country offered a reward for the discovery of the cause of the disease. Woronin‡ undertook the investigation, and after years of patient study published an elaborate account, proving clearly that the disease was caused by a minute organism related to the fungi, to which he gave the name *Plasmodiophora brassicæ*.

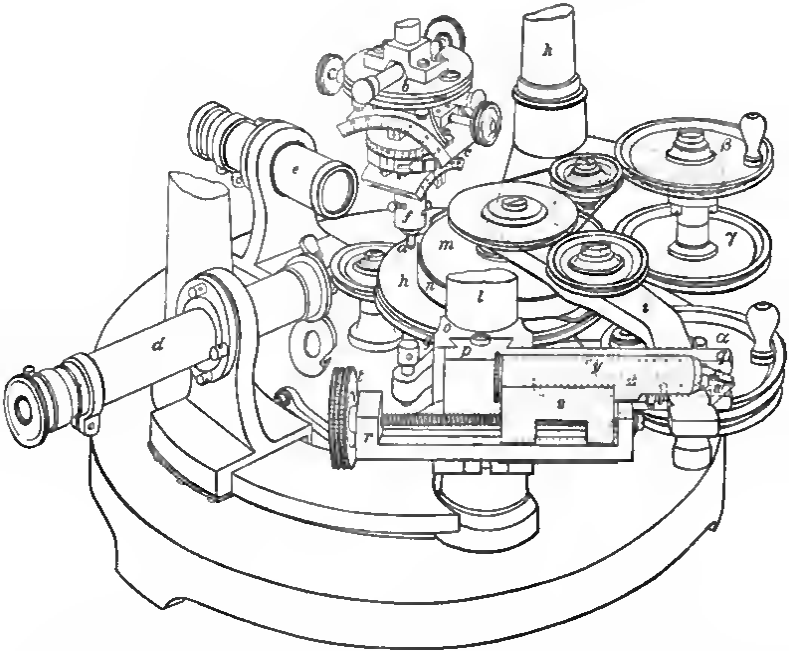
In 1859, Voelcker§ pointed out that the disease was influenced by the amount of lime present in the soil. Where little or no lime existed, as in light and sandy soils, the disease abounded, whereas in

* New Jersey Agric. Coll. Expt. Station; Bull. 98 (1893).

† 'Gard. Chron.,' p. 500, 1856.

‡ 'Pringsheim's Jahrb.,' vol. 11, p. 548, tabs. xxix—xxxiv (1878).

§ 'Roy. Agric. Soc. Journ.,' vol. 20, p. 101 (1859).



Instrument for Cutting, Grinding, and Polishing Section-plates and Prisms of Mineral or other Crystals.